Range Enhancement to Wide Area Multilateration Processing

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Detect the Difference

Presentation Goals

Demonstrate the range enhancement to multilateration processing significantly extends the range and receiver siting flexibility of wide area multilateration systems

Presentation Topics

➢ Limitation of current multilateration processing

➢ Range enhancement to multilateration processing

➢ Benefits of the range enhancement

➢ Performance results of a developmental system with the range enhancement

Current Processing Techniques

➢ Constellation of sensors receive a single aircraft transmission at multiple points in space

➢ TDOA used to determine a very accurate position estimates

– Eliminates transponder turn around errors

➢ GDOP is the predicted accuracy of a multilateration system at any point in space

Mathematical Limitations

➢ GDOP is relatively small and constant inside a constellation of receivers

➢ GDOP increases rapidly outside a constellation of receivers

➢ Target localization impractical a short distance outside boundary of receivers
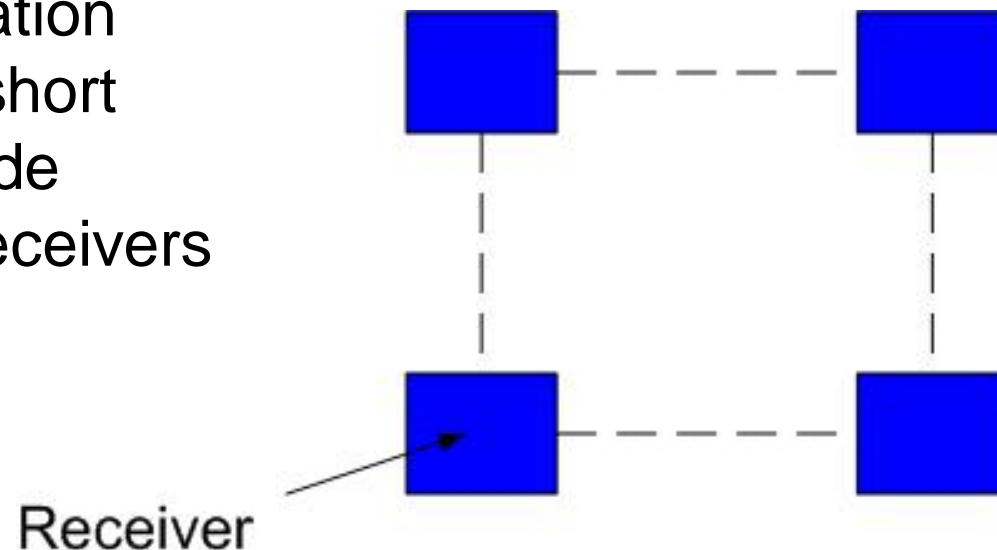
Receiver

System Limitations

➤ Surveillance over a wide area requires a broad deployment of receivers

➤ Distributed receivers present logistical issues:
- Site access
- Communications
- Security

➤ Desirable to provide high quality multilateration surveillance while minimizing distribution of receivers

Range Enhancement

➔ Multilateration systems use interrogations for:
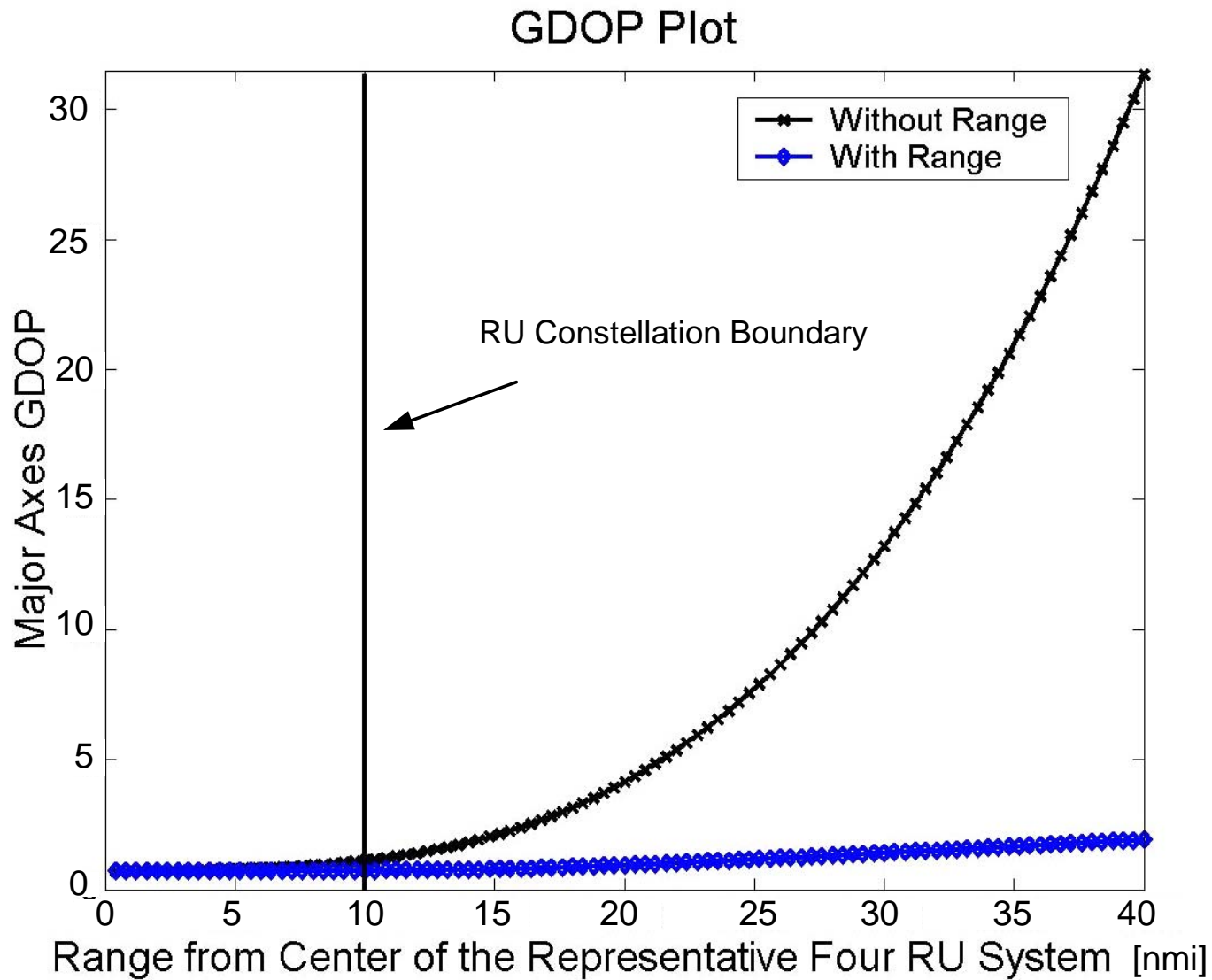 – ATCRBS tracking
  – Mode A code
  – Mode C altitude

➔ Range from interrogator can be measured for each interrogation/reply transaction
  – Compensating for transponder turn around time delay

➔ Comparable to current SSR surveillance

➔ Significantly improves GDOP outside the boundary of receivers

# GDOP Comparison

GDOP Plot

Benefits of Multilateration w/ Range

➢ Juneau (Alaska) International Airport terminal area is dominated by mountainous terrain

➢ Multiple rotating radars needed to provide surveillance
  – Terrain limited

➢ Distributed solution like multilateration is the ideal solution
  – Flexible siting

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Juneau Terminal Airspace
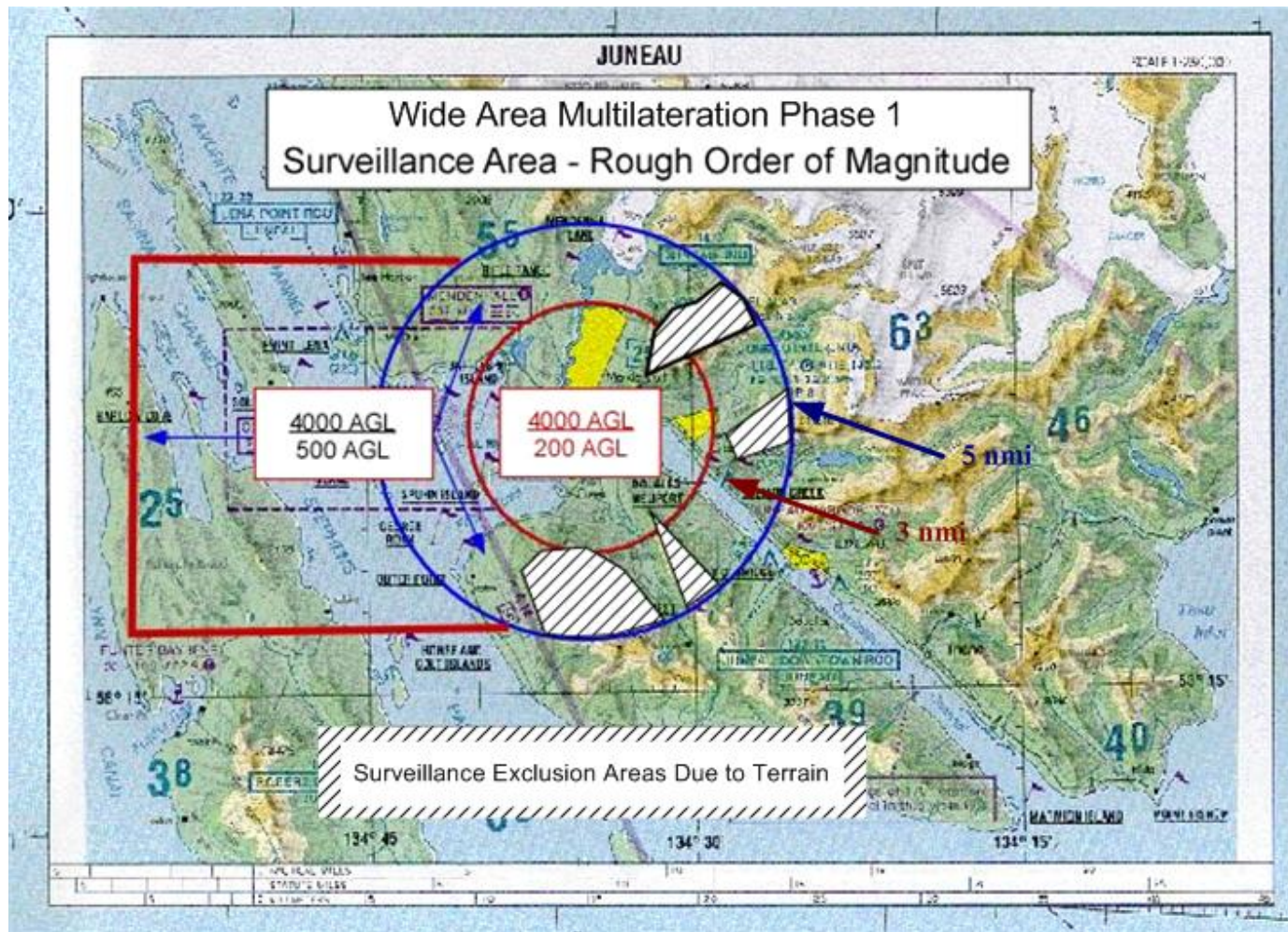
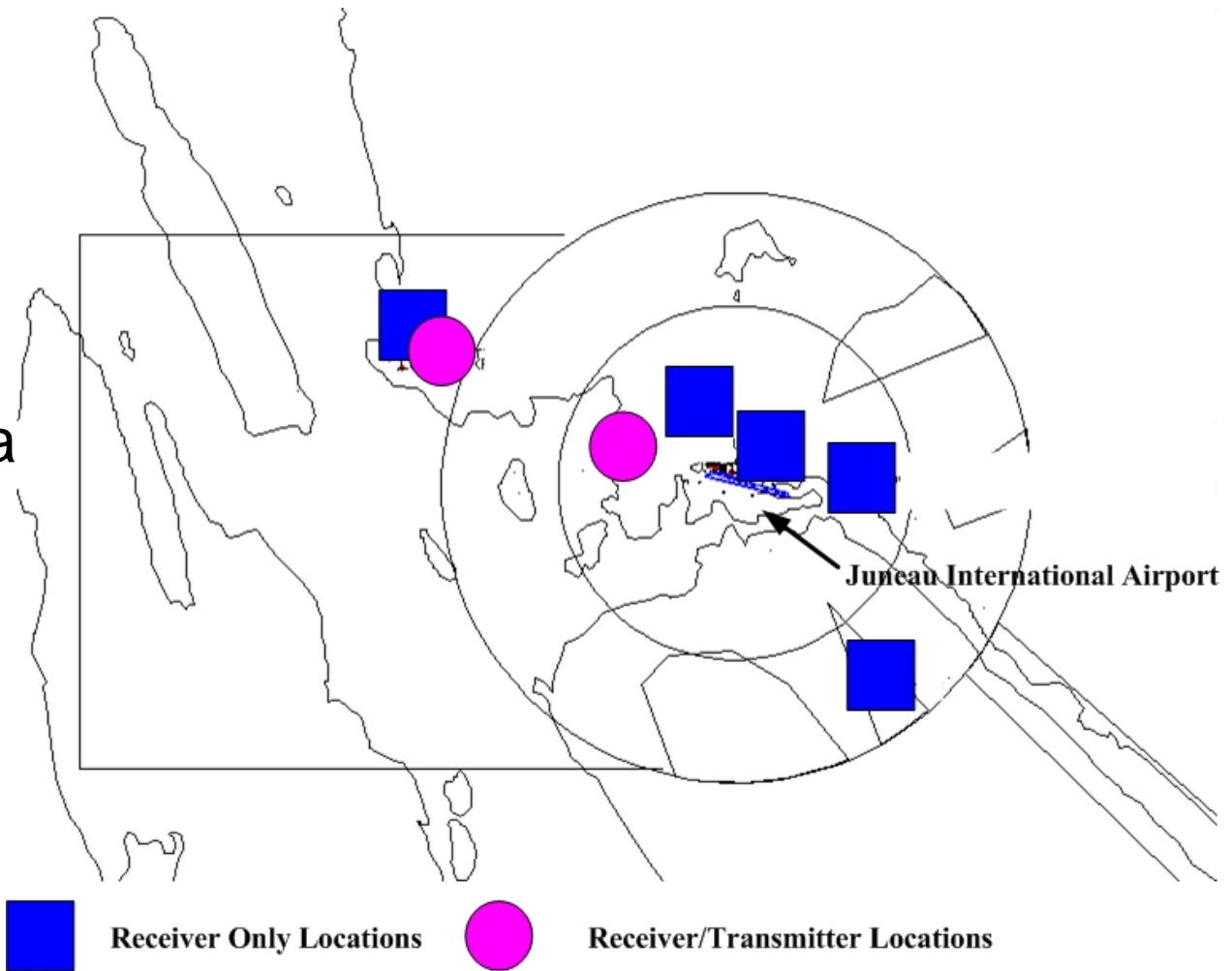# Juneau Multilateration Siting

→ **Limited siting options**
  - Terrain
  - Communications
  - Power

→ **Ideal receiver locations surround coverage area**
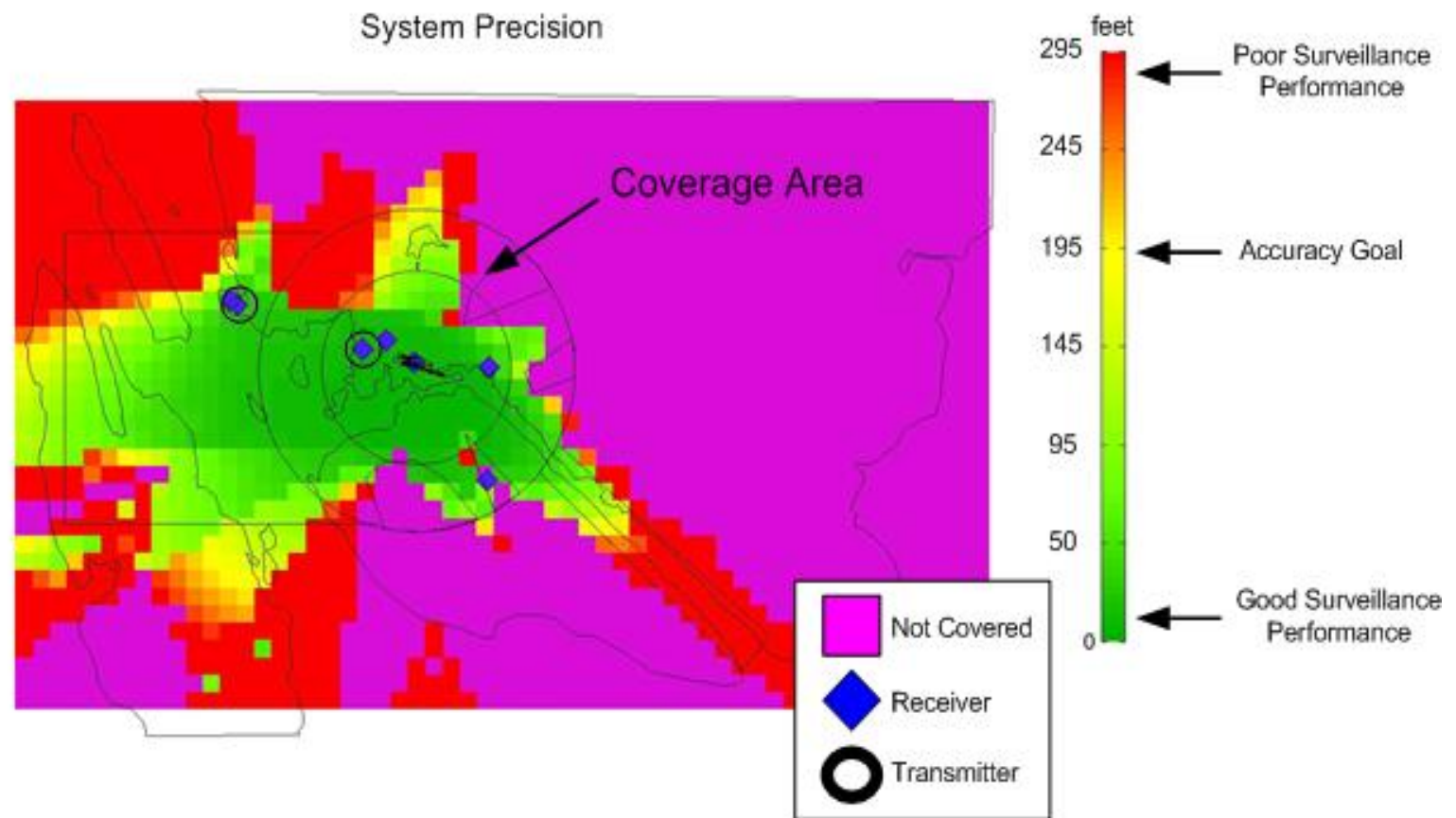
→ **System configuration**
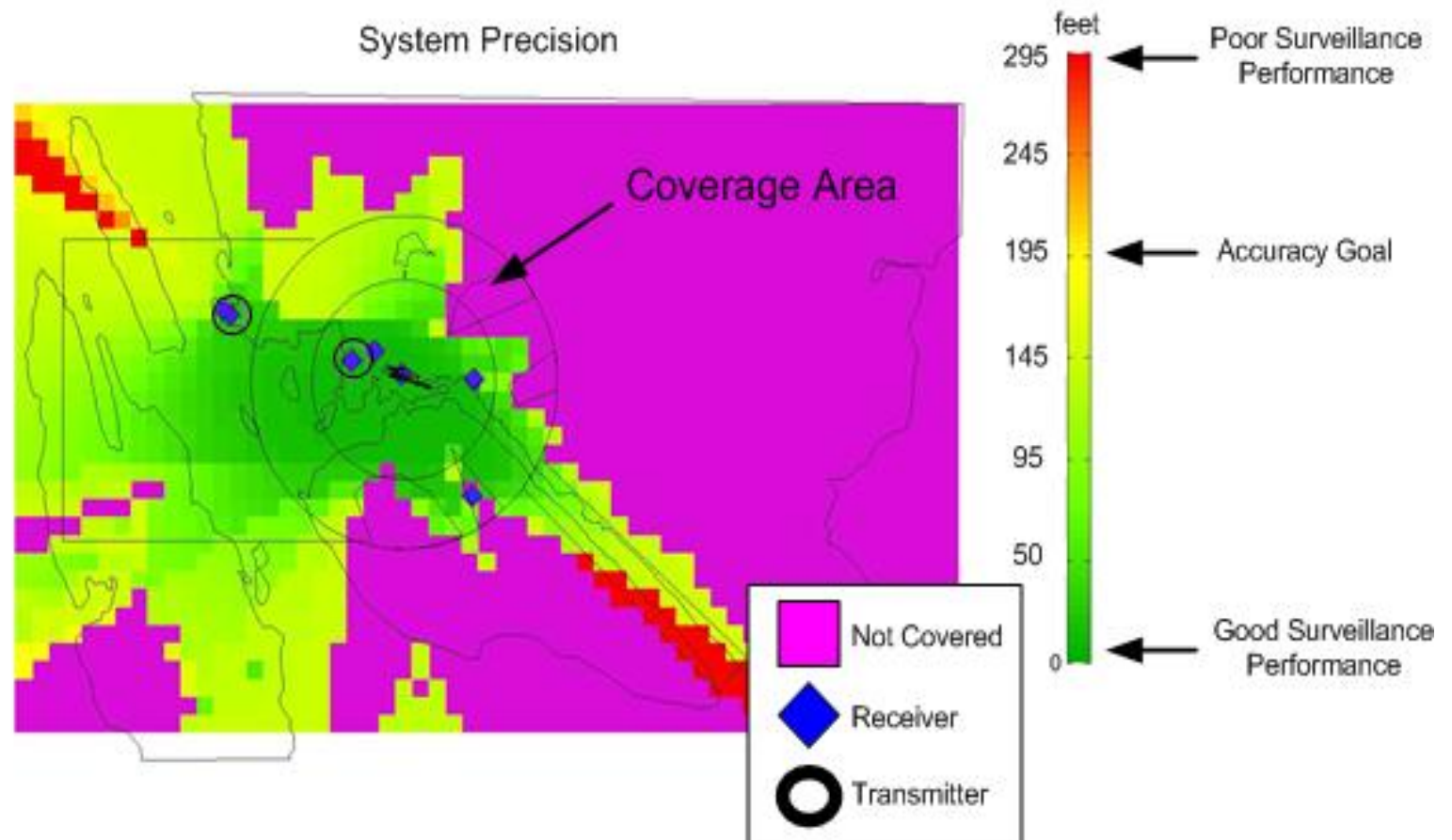 - 5 receivers
  - 2 receiver/transmitters

Juneau International Airport

■ Receiver Only Locations   ● Receiver/Transmitter Locations

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Traditional Multilateration Simulation

⤳Poor surveillance over large potion of coverage area
- Poor GDOP

System Precision

Not Covered

◆ Receiver

○ Transmitter

Range-Aided Multilateration Simulation

✈ Good surveillance over entire coverage area

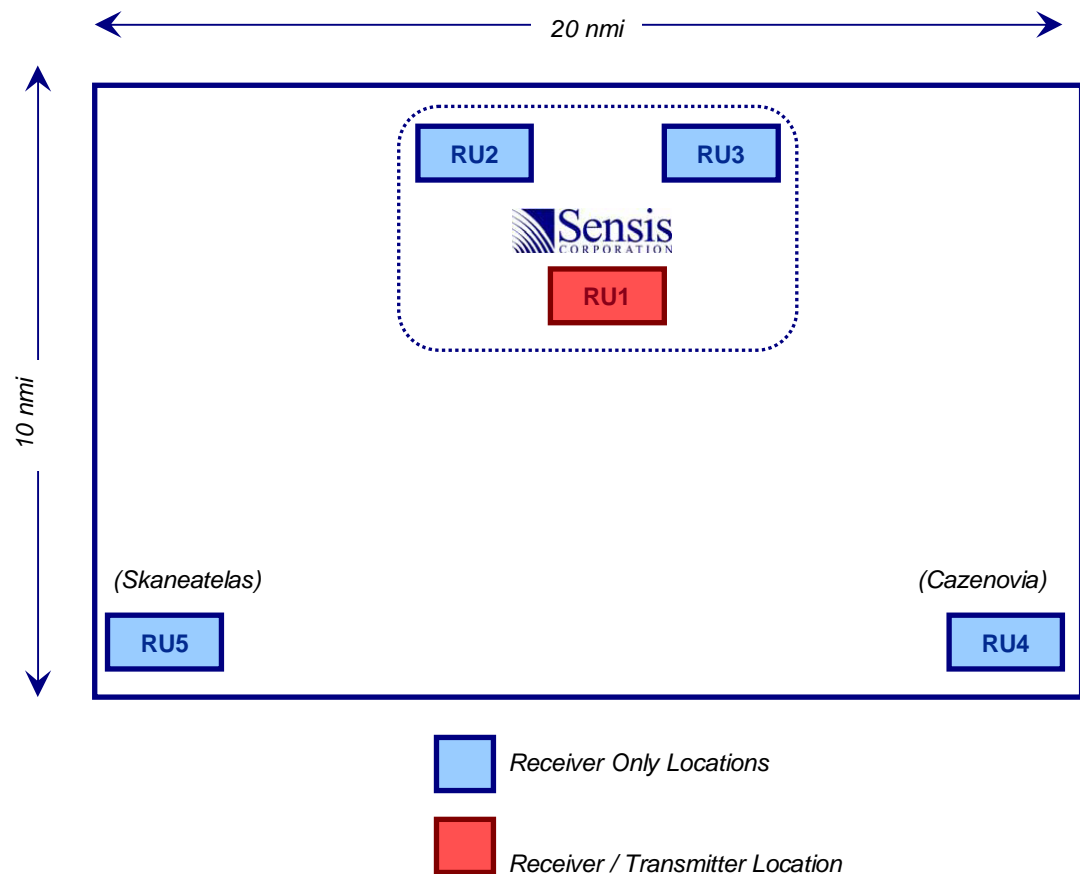- Accuracy
- Probability of detection

Developmental System

➤ System deployed around Sensis Corporation

– Range enhancement

– 4 Receivers

– 1 500 W Tx/Rx

– 60 nmi range

– 50 int/s max

– GPS timesync

20 nmi

10 nmi

RU2   RU3

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RU1

(Skaneatelas)   (Cazenovia)

RU5   RU4

☐ Receiver Only Locations

☐ Receiver / Transmitter Location

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Mode S Flight Test

→ Volpe Transportation Center Test Aircraft

- – Differentially corrected GPS truth source

- – 8800 ft AGL

- – Belly mounted transponder

→ Test aircraft acquired 40 nmi from Sensis Corp

- – 5 second acquisition time

- – Altitude line of site

→ 3 small gaps when target banks
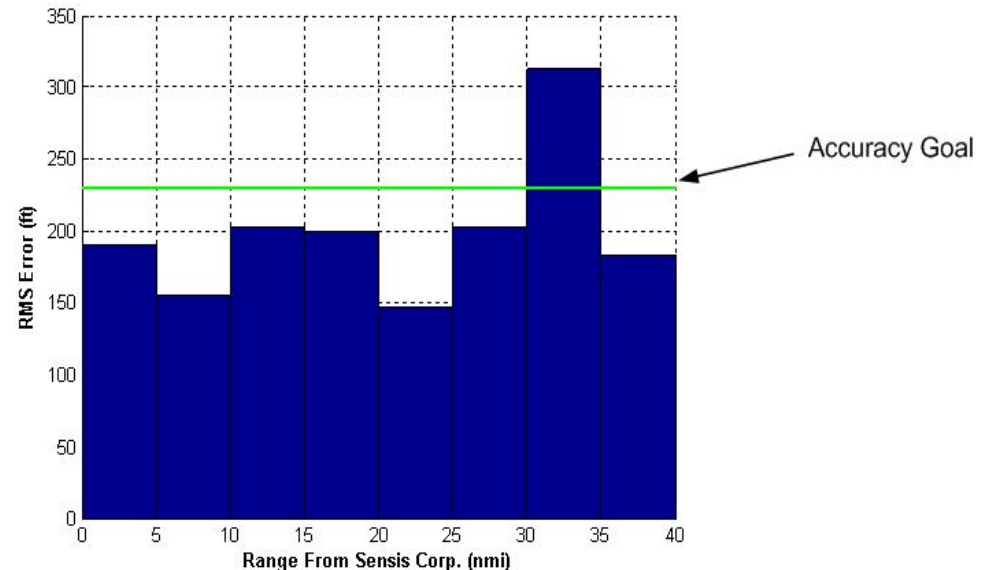
- – No receiver detection

Flight Test Profile

No Receiver Detection

Legend:
- Multilateration
- GPS Truth

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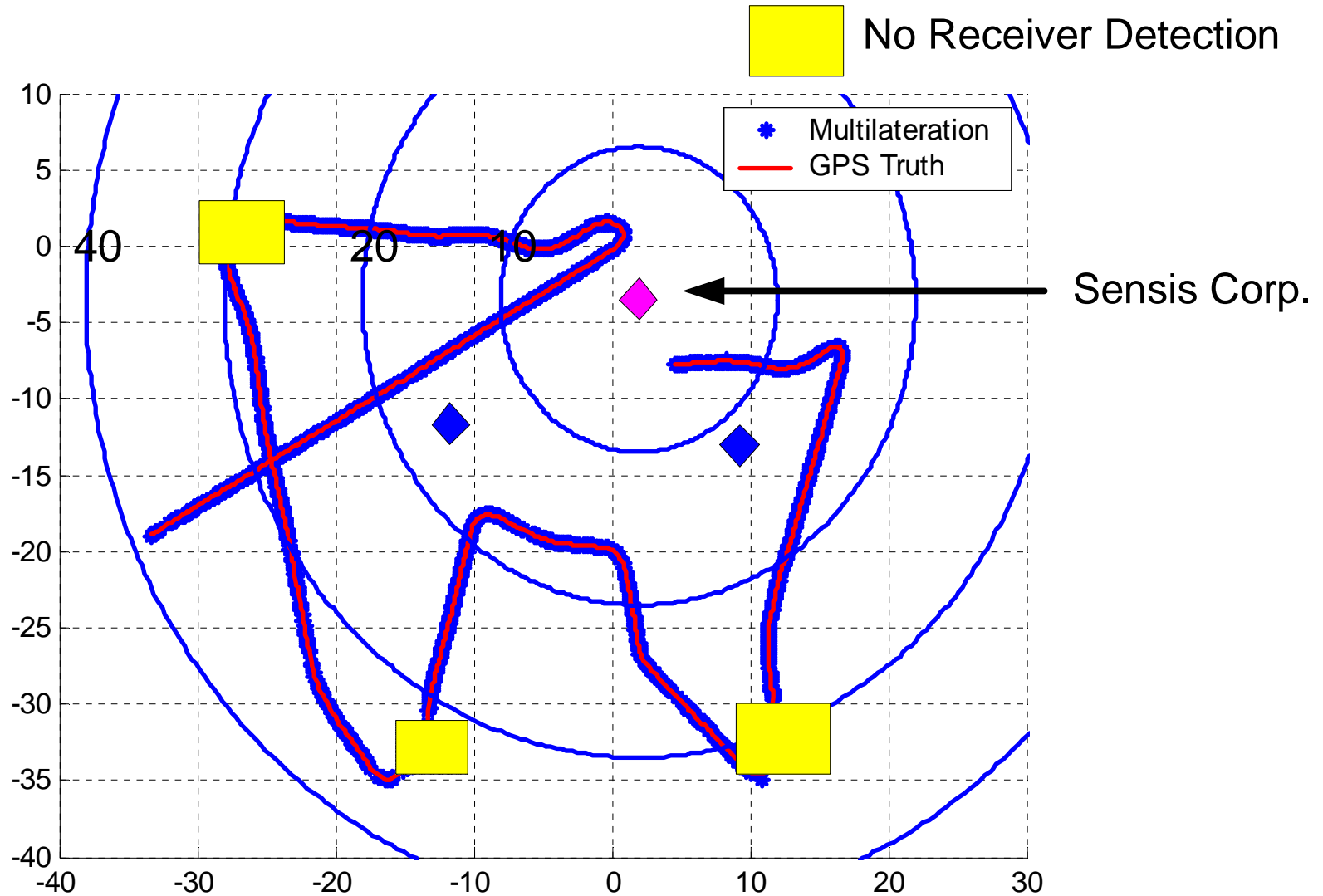
Flight Test Results

➢ **200 ft RMS absolute error**
- – 95% of positions <= 328 ft
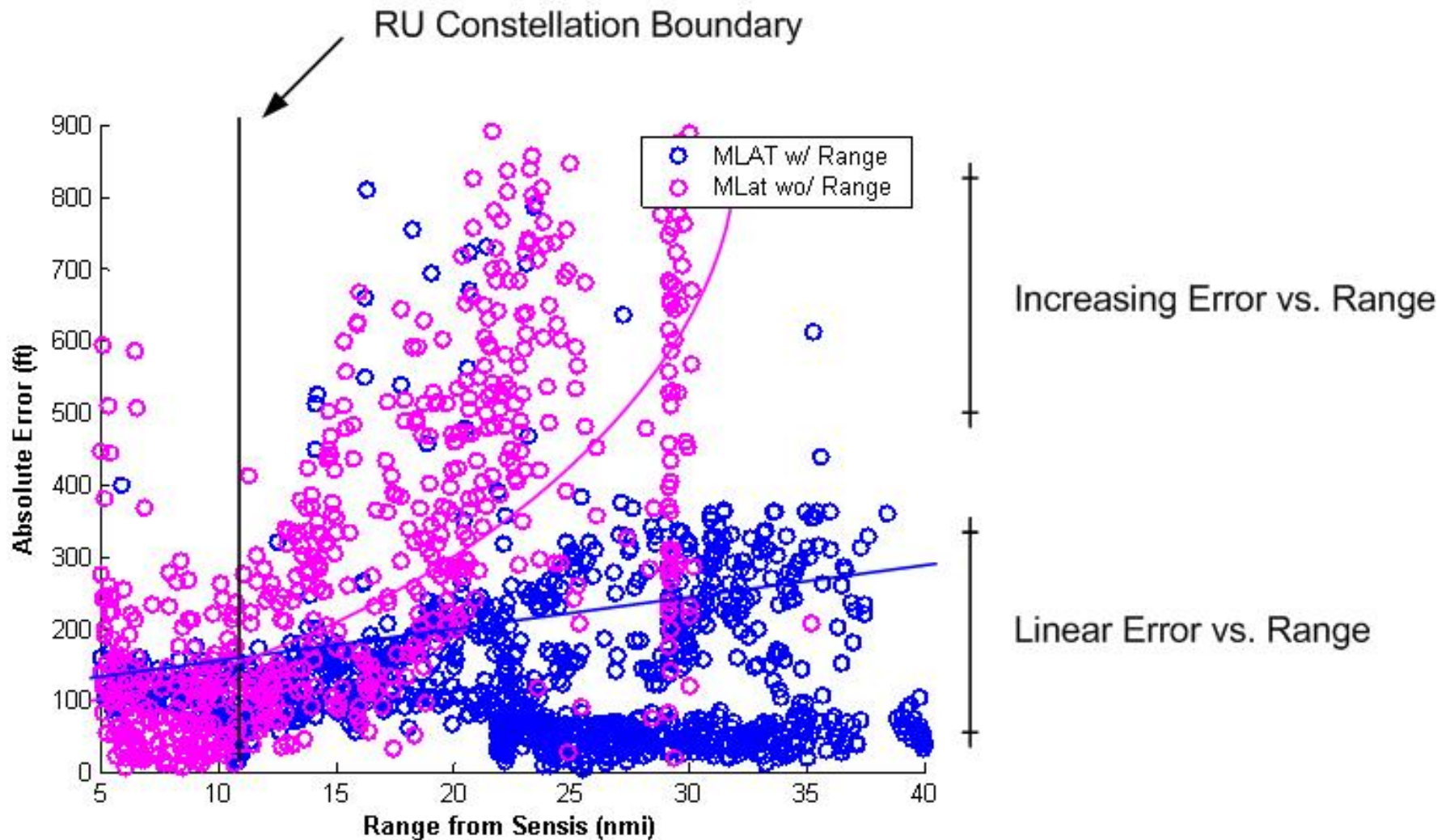- – 99.9% of positions <= 984 ft

➢ **0.93 probability of update in 5 second interval**

➢ **Increased error at 30 -35 nmi due to poor detection during turn**

Processing Technique Comparison

Applications

➢ Comparable to terminal and en-route surveillance
  – Accuracy
  – Update rate

➢ Increased update rate applications require additional interrogations or distributed receiver architecture
  – Precision Runway Monitor

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Conclusions

➔ **Range enhancement significantly increases siting flexibility**
  - Reduced receiver distribution
  - Efficiently utilize existing infrastructure

➔ **Range enhancement significantly improves target localization outside a constellation of receivers**

➔ **Surveillance performance comparable to current SSR technology**